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A NOVEL DESIGN TECHNIQUE FOR VARIABLE FIBER LENGTH OF 32-CHANNEL DWDM SYSTEM WITH HYBRID AMPLIFIER AND DCF

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ABSTRACT

The majority of telecommunication service providers use DWDM systems which allow expansion of existing capacity without laying additional fiber optic cables. For the successful transmission of optical signals over long distance single mode fibers and EDFA are used. The performance is degraded if single mode fiber is used because of nonlinear effects like dispersion, FWM etc. To ensure the communication quality, reduction of these nonlinear effects becomes essential. This paper proposes a novel design technique which aims at improvement in performance of a DWDM system by the usage of hybrid amplifier and dispersion compensated fiber. Performance of the proposed system is analyzed for different fiber length of 50km, 80km and 100km. Optisystem 13.0 is the software used for the analysis of the design study. The results obtained shows that the Q- factor is very much enhanced by the proposed system while BER is very much reduced. The impact of the fiber length studied here shows that if the fiber length is increased beyond 80km the Q- factor is very much degraded and BER is increased.

Keywords: DWDM, hybrid amplifier, DCF, different fiber length, Q-factor and BER.

1. INTRODUCTION

Ease of Use Optical fiber can be used as a medium for telecommunication and networking because it is flexible and can be bundled as cables. It is especially advantageous for long distance communications, because light propagates through the fiber with little attenuation compared to electrical cables.

In fiber-optic communications, wavelength-division multiplexing **(WDM)** is a technology which multiplexes a number of optical carrier signals onto a single optical fiber by using different wavelengths of laser light. Lasers are capable of creating pulses of light with a very precise wavelength. Each individual wavelength of light can represent a different channel of information.

WDM systems are divided in different wavelength patterns, *coarse* and *dense* WDM. Conventional WDM systems provide up to 8 channels in the 3rd transmission window (C-Band) of silica fibers around 1550 nm. Dense wavelength division multiplexing (DWDM) uses the same transmission window but with denser channel spacing. It can carry different types of traffic at different speeds over the channel.

The performance of the DWDM system is specified by the Bit Error Ratio and Q-factor.BER is the rate at which errors occur in a transmission system.

2. BASIC DWDM SYSTEM

The DWDM systems allow the expansion of the existing network without laying additional fibers. The capacity of the existing system is expanded using multiplexers and demultiplexers at the ends of the system [4].

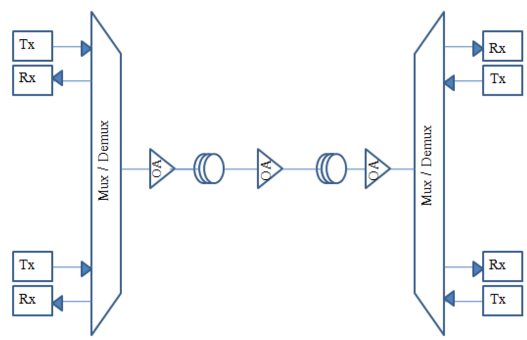

Figure-1. DWDM system block diagram.

The terminal multiplexer actually contains one wavelength converting transponder for each wavelength signal it will carry. The wavelength converting transponders receive the input optical signal (i.e., from a client-layer SONET/SDH or other signal), convert that signal into the electrical domain, and retransmit the signal using a 1550 nm band laser. The terminal mux also contains an optical multiplexer, which takes the various1550 nm band signals and places them onto a single fiber. The terminal multiplexer may or may not also support a local EDFA for power amplification of the multi-wavelength optical signal. For the successful transmission of optical signals over long distances, doped fiber amplifiers with erbium (EDFA – Erbium Doped Fiber Amplifier) are used. Erbium is a rare element and, when excited, it is emitting the light at a wavelength of 1,54 μm, which is the wavelength at which the attenuation of signal power is minimal. Weak signals enter the erbium doped fiber, in which light is injected by lasers pumps. This light excites erbium atoms, and the atoms are releasing the accumulated energy in a form of additional light with wavelength around 1550 nm. As this process

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continues through the fiber, the signal is amplified. EDFA is available in the C and L windows but with quite narrow range (1530-1560 nm).

3. PROPOSED DWDM SYSTEM

An optical communication system consists of transmitter, communication channel and receiver. The role of the optical transmitter is to convert the electrical signal into optical form and launch the resulting optical signal into the optical fiber. Optical signals were transmitted through optical fiber to the optical receiver [1].

a) Transmitter design

The role of optical transmitter is to convert the electrical signal into optical form. It consists of optical source, an electrical pulse generator and an optical modulator. Mach-Zehnder external modulator model was used in system design [3]. The system consist of 32 channels hence 32 such modulators are used and array laser is deployed to feed the signals.

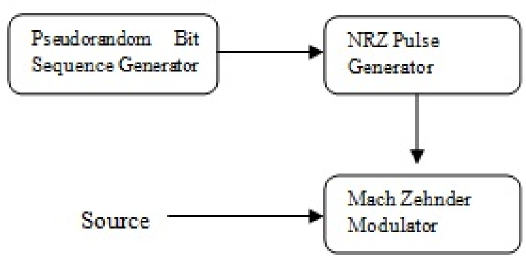

Figure-2. Externally modulated transmitter.

b) Channel design

Optical amplifiers (OAs) boost the amplitude or add gain to optical signals passing on a fiber by directly stimulating the photons of the signal with extra energy. Optical amplification uses the principle of stimulated emission, similar to the approach used in a laser.

EDFA is used before feeding the signal to RAMAN and SMF. There are mainly three reasons for the interest in Raman amplifier. First its capability to provide distributed amplification second is the possibility to provide gain at any wavelength by selecting appropriate pump wavelengths, and the third is the fact that the amplification bandwidth may be broadened simply by adding more pump wavelengths. An important feature of the Raman amplification process is that amplification is achievable at any wavelength by choosing the pump wavelength in accordance with the signal wavelength [10].

Raman gain arises from the transfer of power from one optical beam to another that is downshifted in frequency by the energy of an optical phonon. The most important feature of Raman-gain spectrum is that the peak-gain wavelength only depends on the pump wavelength.

Here RAMAN amplifier employed with the length of 60Km. This RAMAN fiber is pumped with laser array with pumping powers of 400 mW. The pumping laser array consists of 6 lasers. Equally spaced WDM multiplexer is deployed for pumping the laser array [2].

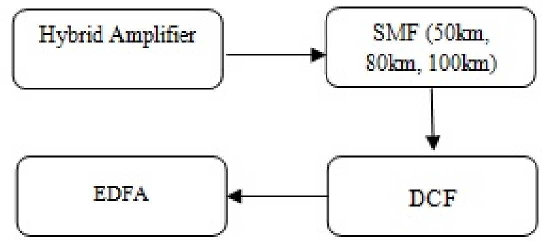

Figure-3. Transmission link.

The most fundamental reason that restrict the transmission of high-speed signals on the 1550nm optical fiber is the linear dispersion, the dispersion of SMF is 17 ps/(nm·km), therefore the DCF should be used for compensating their dispersion performance. DCF's chromatic dispersion is negative (dispersion coefficient is – 90 ps/(nm·km),its dispersion characteristics is coincides contrary with the SMF's, if the length of DCF is the SMF's 1/5, then the total transmission line dispersion value close to zero. However, the DCF attenuation is larger, to solve this problem, EDFA was added to compensate linear loss after the DCF and near to the receiver [1].

c) Receiver design

The role of optical receiver is to convert the optical signal into electrical form. It is composed of the photoelectric detector, filters and regenerators. In this design PIN detectors and Bessel low pass filter whose cut of frequency is 0.75*Bit rate are selected.

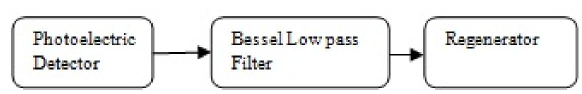

Figure-4. Receiver.

4. RESULTS

The Table-1 shows that the simulation results of a 32 channel DWDM system using hybrid amplifier with and without DCF for 50km fiber and 10gbps data rate.

Table-1. Proposed DWDM system for 50 km fiber.

DWDM system with hybrid amplifier	Q-factor	BER
Without DCF	6.27	10^{-10}
With DCF	18.85	10^{-80}

The eye diagram shown in Figure-5 is taken without using any dispersion compensation technique. Hence SNR of the received signal is decreased due to inter symbol interference.

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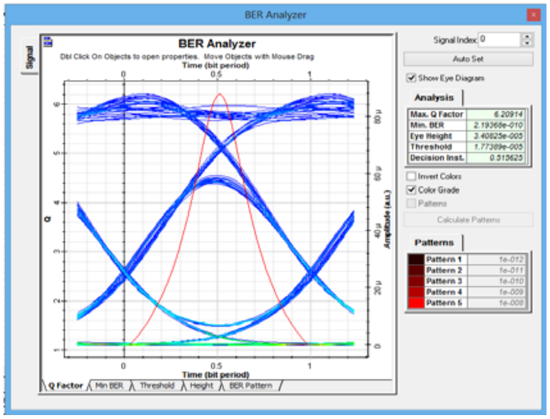

Figure-5. Eye Diagram without dispersion compensation.

Figure-6 shows the Q factor after dispersion compensation technique. Here Q-factor is improved and bit error rate is decreased.

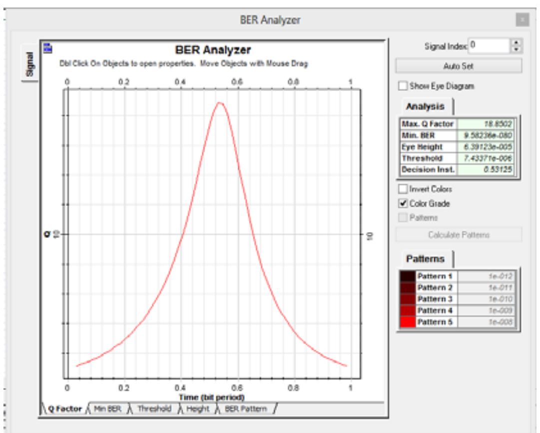

Figure-6. Q-Factor after dispersion compensation.

Eye-diagram after using dispersion compensation is shown in Figure-7.

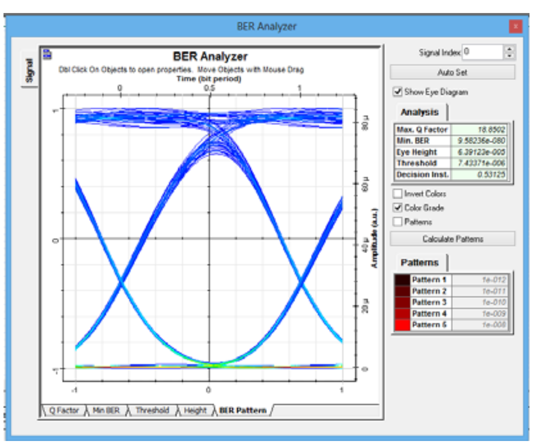

Figure-7. Eye diagram with dispersion compensation.

Table-2 shows the Q-factor and BER of variable fiber length with different data rate .As data rate increases Q-factor decreased and BER increased.

Table-2. Proposed DWDM system for variable fiber length and data rate.

Parameters	**Fiber length**	**Data rate in gbps**			
		5	10	20	40
Q-factor	50	59	18.85	3.46	2.09
	80	18.743	13.638	2.86	2.106
	100	5.45	-	-	-
BER	50	0	10^{-80}	10^{-4}	10^{-2}
	80	10^{-78}	10^{-42}	.0017	.015
	100	10^{-48}	-	-	-

5. DISCUSSIONS

The 200GHz channel spacing wavelength is selected in this design in order to reduce inter-symbol crosstalk. The data rate used for simulation is 10 Gb/s. Sequence length of 128 Bits, sample per bit equal to 64 and number of samples equal to 8192 are used for simulations. Dispersion compensated fiber has a lot of linear loss which should be considered while designing the channel. Here in addition to hybrid amplifier, a EDFA of gain of 5db and a noise index of 6db has been added after DCF to compensate for SMF and DCF linear loss.

Due to chromatic dispersion in SMF, signal is broadened over a larger bandwidth than the transmitted one. The Q-Factor obtained is 6.27 and BER 10^{-10}. This is shown in Figure-5.

In this case, it becomes quite difficult to distinguish the data transmitted by various channels; since the data are correpted by high BER and low Q-factor . In order to achieve Q-Factor and BER to be of acceptable range, some dispersion compensation technique is needed to be used.

After using dispersion compensation, the signal is restored hence the Q factor is increased. It found that in this design Q-Factor has been increased to 18.85 while BER has been decreased to 10^{-80}. Also eye opening has been broadened. Jitter has also been reduced.

Similarly the eye diagram s for 50km, 80km and 100km with different data rate are simulated. These results are shown in Table-2.

Case1: For 50km fiber length the Q-factor and BER is acceptable up to 10gbps data rate.

Case2: For 80km also the parameters are acceptable up to 10gbps but Q-factor is reduced and BER increased.

Case3: For 100km fiber the Q-factor and BER is acceptable only for 5gbps data rate.

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This design considers only chromatic dispersion and not other non-linear effects like XPM, FWM.

6. CONCLUSIONS

A 32 channel DWDM communication system with hybrid amplifier and DCF is designed and investigated through OptiSystem13. Here externally modulated transmitter is used to achieve stability and reduced non-linear effects. The hybrid amplifier with dispersion compensation technique provides better Q factor and minimum BER. In this system simple Raman amplifier is used. Better results may be obtained by using distributed Raman amplifier. This should be studied further.

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